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Richerand

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(54) **METHOD AND APPARATUS FOR
SEPARATION OF FLUIDS WITHIN A SINGLE
VESSEL**

USPC 210/703, 802, 804, 806, 202, 221.2,
210/522, 201, 320
See application file for complete search history.

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(56) **References Cited**

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U.S. PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 453 days.

3,773,179	A *	11/1973	Hurst	210/194
3,986,954	A *	10/1976	George et al.	210/706
4,800,025	A *	1/1989	Bibaef	210/703
4,824,579	A *	4/1989	George	210/703
4,935,154	A *	6/1990	Arnold	210/787
4,983,287	A *	1/1991	Arnold	210/259
5,158,678	A *	10/1992	Broussard, Sr.	210/221.1
5,509,535	A *	4/1996	Schneider	209/169
5,814,229	A *	9/1998	Lygren	210/703

(21) Appl. No.: **13/208,852**

(22) Filed: **Aug. 12, 2011**

* cited by examiner

Related U.S. Application Data

(60) Provisional application No. 61/449,289, filed on Mar.
4, 2011.

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B03D 1/14 (2006.01)
B03D 1/24 (2006.01)
B01D 17/02 (2006.01)
C02F 1/40 (2006.01)
C02F 103/36 (2006.01)

(52) **U.S. Cl.**

CPC **B01D 17/0205** (2013.01); **C02F 1/24**
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17/0211 (2013.01); **B01D 17/0214** (2013.01);
B03D 1/1406 (2013.01); **B03D 1/1456**
(2013.01); **B03D 1/1493** (2013.01); **C02F**
2103/365 (2013.01)

(58) **Field of Classification Search**

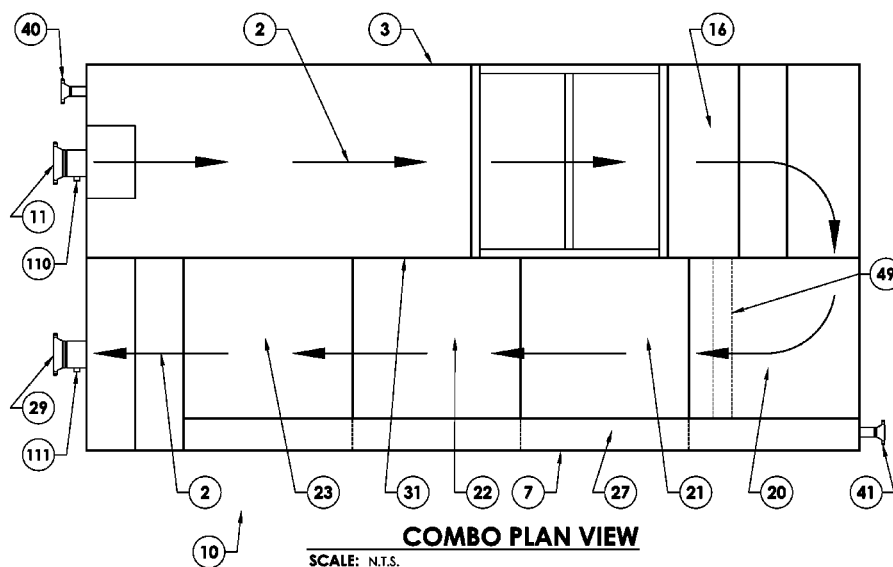
CPC C02F 1/24; C02F 1/40; C02F 9/00;
B01D 17/0205; B03D 1/1456

(57)

ABSTRACT

A process wherein a combination of two separation principles are combined into one space saving machine with portability to separate two distinct and different fluids one lighter in specific gravity than the other, including the steps of primary separation of fluids allowing for free and suspended solids along with free oil and grease to be removed in the primary separation chamber; utilizing parallel corrugated plates in the separation defining the distance of rise for a given oil droplet based on Stokes Law to remove the remaining large droplets of free oil and solids; and providing an induced gas flotation process which provides a finely dispersed bubble in the liquid to accelerate the lift necessary for separation of fine oil droplets, emulsified oil droplet, and suspended solids to meet a government discharge regulation. This combined technique can be configured in a single vessel without pumps or other methods of liquid movement.

4 Claims, 7 Drawing Sheets



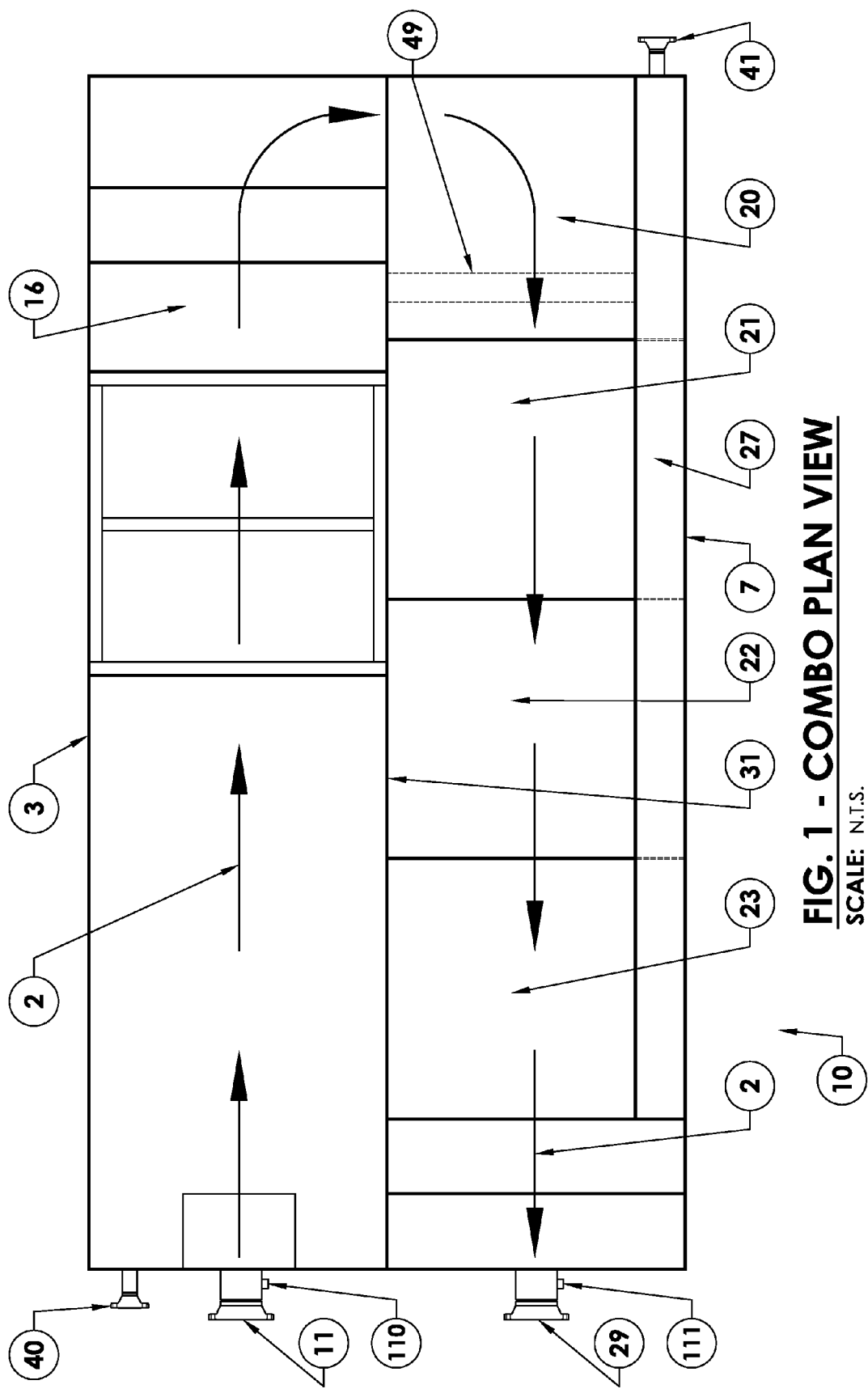
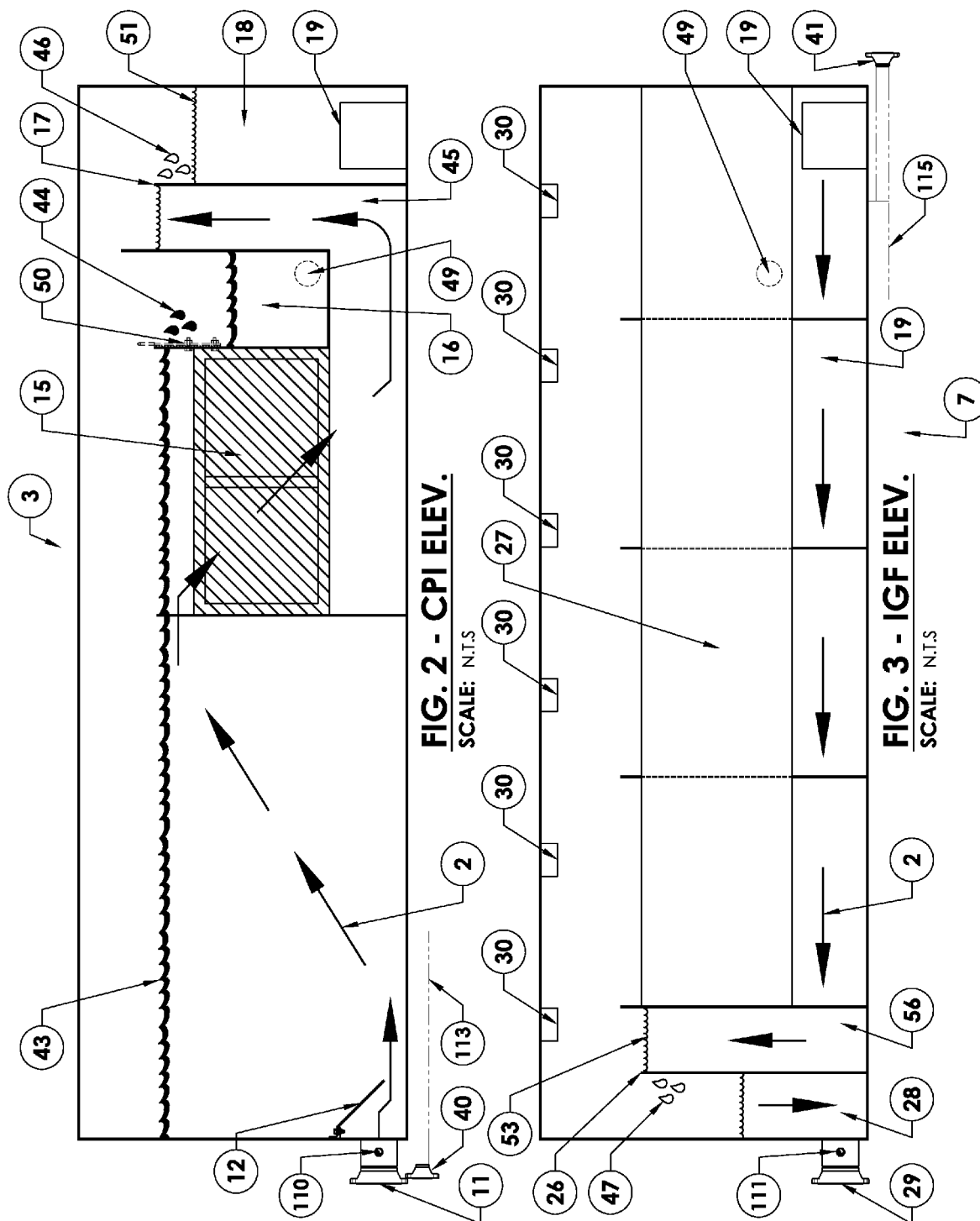


FIG. 1 - COMBO PLAN VIEW
SCALE: N.T.S.



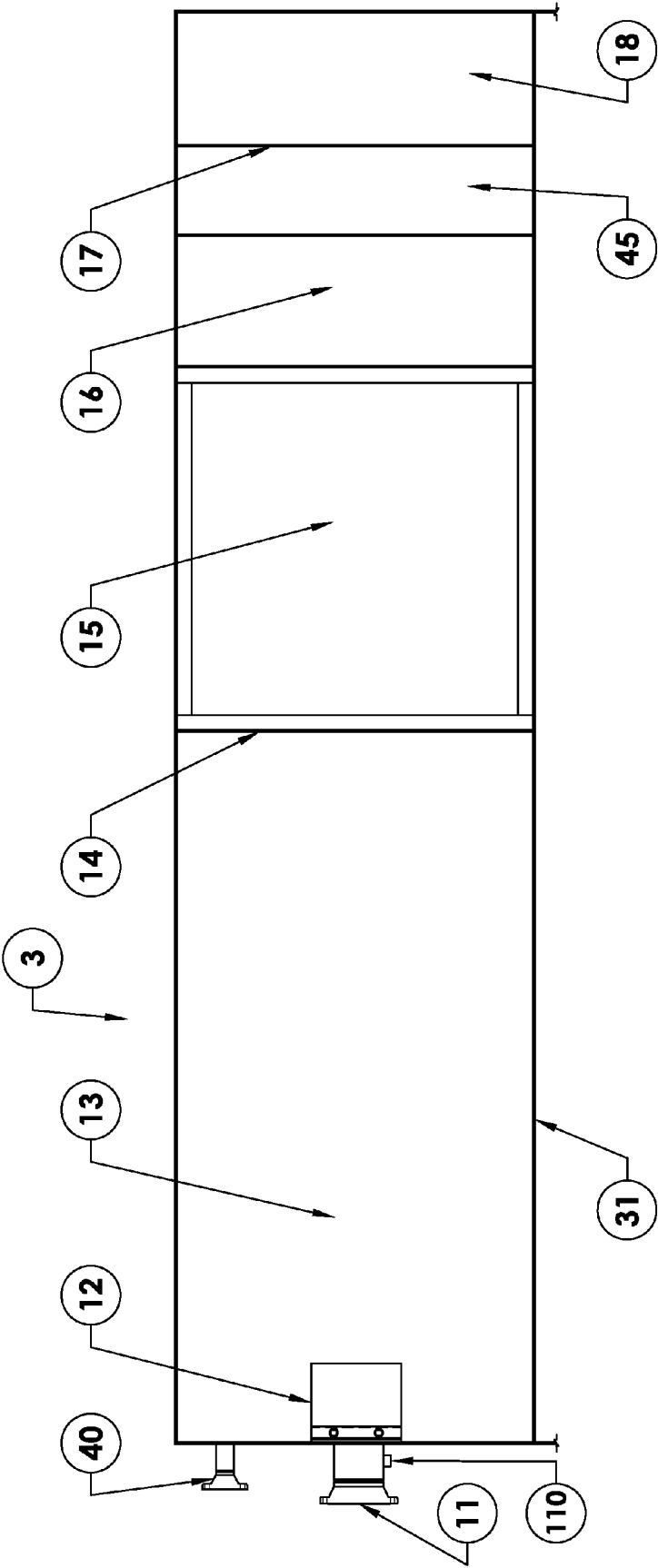


FIG. 4 - CPI PLAN VIEW
SCALE: N.T.S

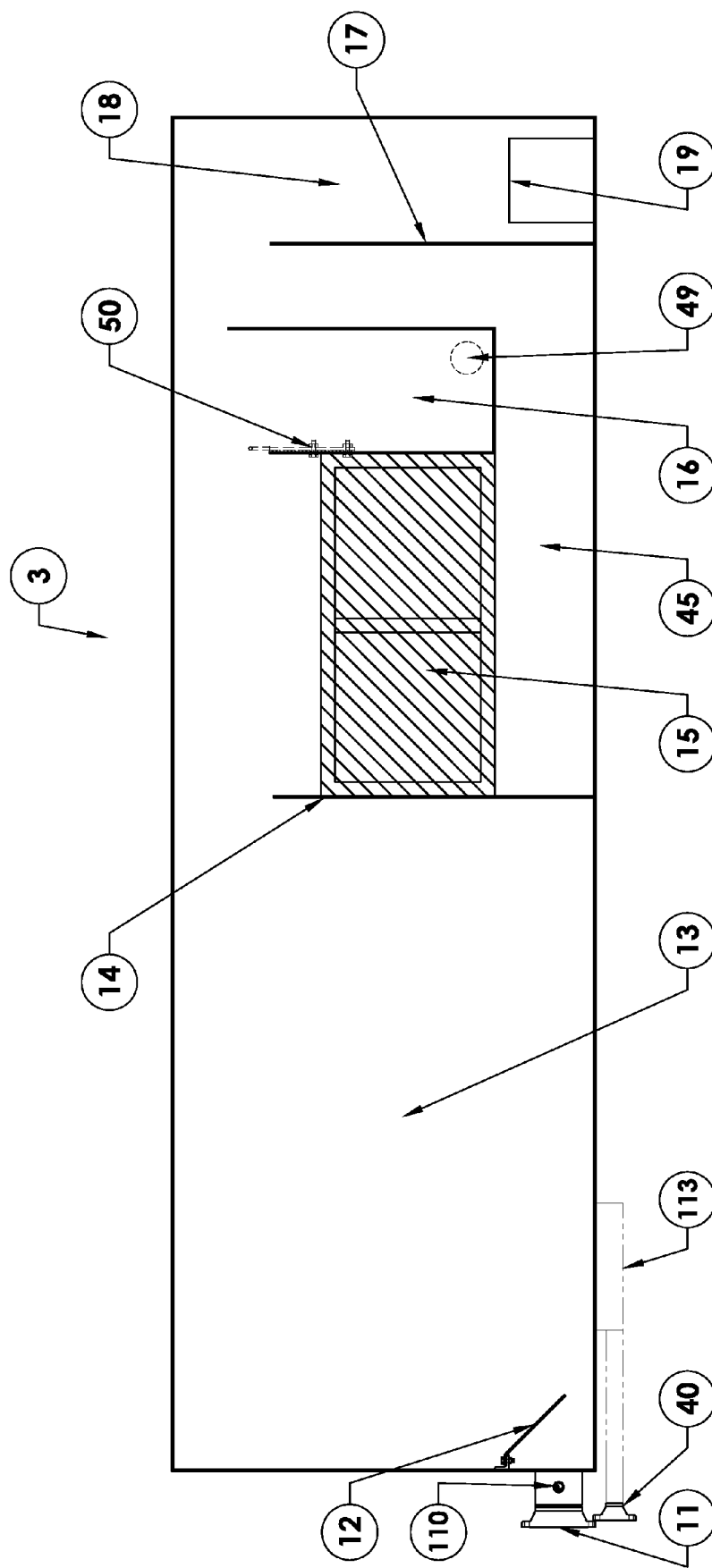


FIG. 5 - CPI ELEV.

SCALE: N.T.S

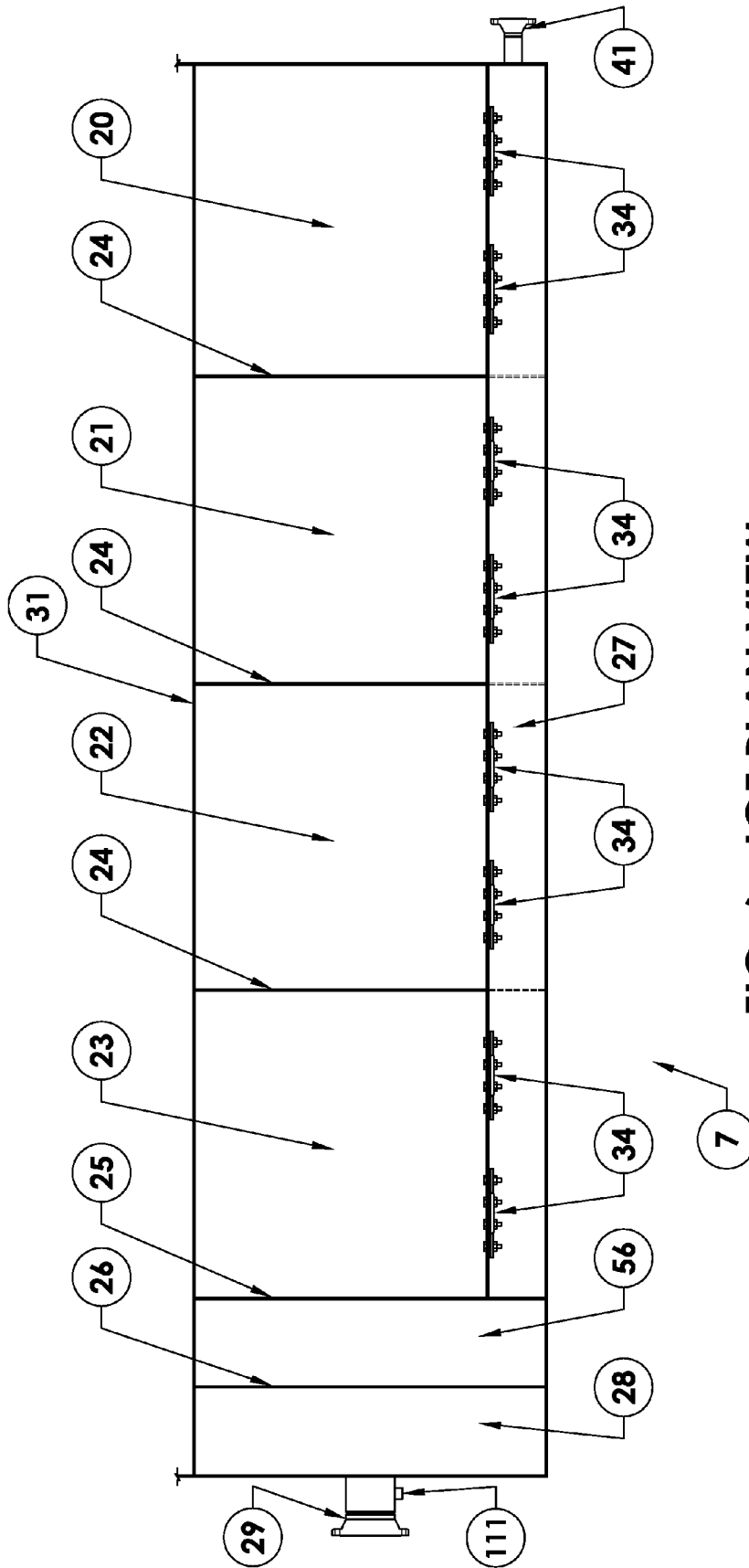
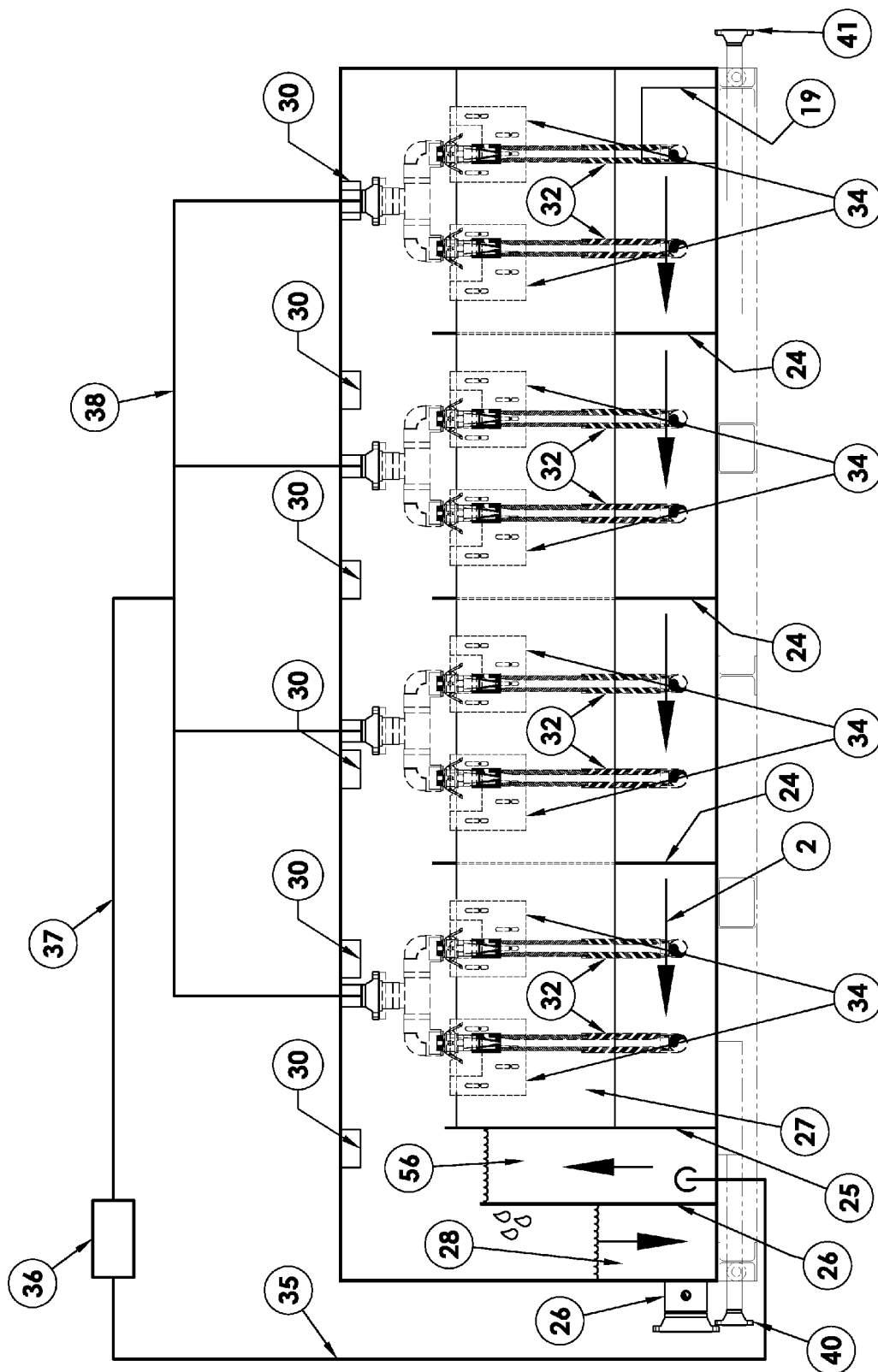


FIG. 6 - IGF PLAN VIEW

SCALE: N.T.S



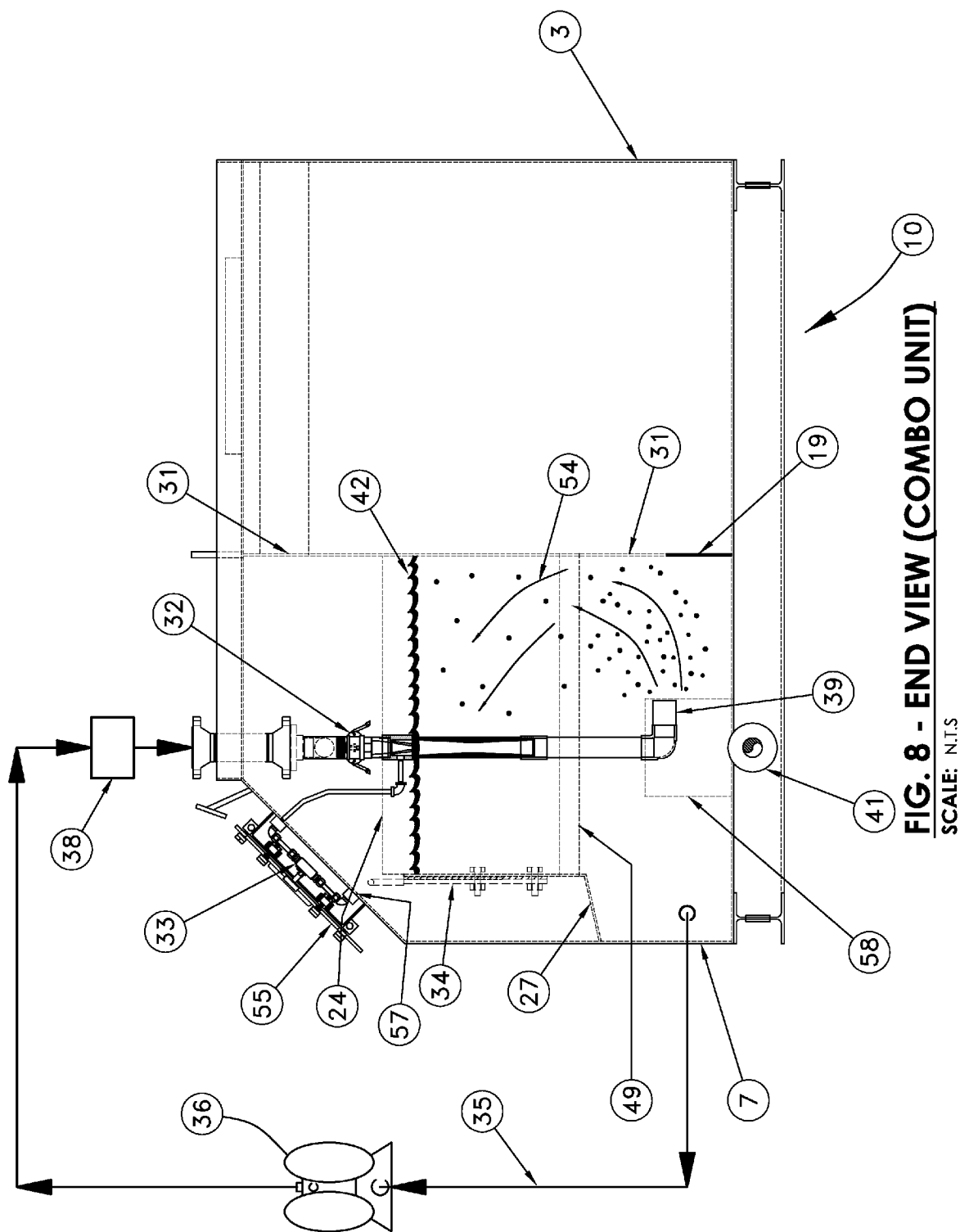


FIG. 8 - END VIEW (COMBO UNIT)

SCALE: N.T.S

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METHOD AND APPARATUS FOR SEPARATION OF FLUIDS WITHIN A SINGLE VESSEL

CROSS-REFERENCE TO RELATED APPLICATIONS

Priority of U.S. Provisional Patent Application Ser. No. 61/449,289, filed Mar. 4, 2011, incorporated herein by reference, is hereby claimed.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to separation of fluids. More particularly, the present invention relates to a method for the separation of two liquids which are immiscible with each other. Still more particularly the present invention discloses a method and an apparatus for separating oil from water efficiently within a single vessel by applying a separating influence and minimizing other factors which tend to reduce droplet size and inhibit separation.

2. General Background of the Invention

In the present state of the art, the separation of two distinct fluids is undertaken in separate operations, which requires additional space, increases the cost and operating expense of having two machines for this operation, and does not allow the equipment to become portable, since these technologies are being operated separately for all of the above applications.

BRIEF SUMMARY OF THE INVENTION

The process and apparatus of the present invention solves the problems in the prior art in that it provides a process wherein a combination of two separation principles are combined into one space saving machine with portability to separate two distinct and different fluids one lighter in specific gravity than the other, including the steps of primary separation of fluids allowing for free and suspended solids along with free oil and grease to be removed in the primary separation chamber; utilizing parallel corrugated plates in the separation defining the distance of rise for a given oil droplet based on Stokes Law to remove the remaining large droplets of free oil and solids; and providing an induced gas flotation process which provides a finely dispersed bubble in the liquid to accelerate the lift necessary for separation of fine oil droplets, emulsified oil droplet, and suspended solids to meet governmental discharge regulations. This combined technique can be configured in a single vessel with the proper flow regime and unique hydraulic condition for undisturbed flow throughout the vessel without the use of pumps or other methods of liquid movement solely thru a specified pressure drop internal to the vessel.

Therefore, it is a principal object of the present invention wherein the combination of these two technologies in one vessel benefits the user in that it minimizes the cost and operating expense of having two machines for this operation.

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It is a further object of the present invention whereby the combination provides a space savings over the current technology.

It is a further object of the present invention whereby the combination makes the equipment portable and therefore can be applied in several ways, primarily as process water treatment equipment, but also for using as equipment bypass treatment while existing equipment is being maintained and finally for pipeline flushes and cleaning and frac water treatment.

It is a further object of the present invention to provide a significant benefit to the state of the art when one considers that to this date all applications of these two techniques have been done in separate and individual equipments while taking up additional space, and having a significantly higher cost, considering the fact there is more equipment, maintenance and instrumentation.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a further understanding of the nature, objects, and advantages of the present invention, reference should be had to the following detailed description, read in conjunction with the following drawings, wherein like reference numerals denote like elements and wherein:

FIG. 1 illustrates a schematic plan view of the present invention;

FIG. 2 illustrates a schematic side elevation view of corrugated plate interceptor (CPI) compartmental vessel of the apparatus of the present invention;

FIG. 3 illustrates a schematic side elevation view of the Induced Gas Flotation (IGF) compartmental vessel of the apparatus of the present invention;

FIG. 4 illustrates a schematic plan view of the corrugated plate interceptor (CPI) compartmental vessel of the apparatus of the present invention;

FIG. 5 illustrates a schematic side elevation view of the corrugated plate interceptor (CPI) compartmental vessel of the apparatus shown in FIG. 4; and

FIG. 6 illustrates a basic schematic plan view of the induced gas flotation (IGF) compartmental vessel of the apparatus of the present invention;

FIG. 7 illustrates a detailed schematic side elevation view of Induced gas flotation (IGF) compartmental vessel of the apparatus of the present invention; and

FIG. 8 schematically illustrates an end elevation view of the composite Enviro-Cell-Combo, comprising the corrugated plate interceptor (CPI), the compartmental vessel, and the induced gas flotation (IGF) compartmental vessel of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a schematic plan view of the present invention, Enviro-Cell-Combo apparatus 10 of the present invention. Enviro-Cell apparatus 10 utilizes an immiscible fluids separation method, incorporating a Corrugated Plate Interceptor (CPI) compartmental vessel 3 conjoint with an Induced Gas Flotation (IGF) compartmental vessel 7 at CPI/IGF process separation partition 31. Schematically illustrated by the immiscible fluid primary flow path 2, the raw immiscible fluid to be separated enters the present invention at immiscible fluid inlet flange 11, the fluid proceeding subsequently through the separation method of Enviro-Cell-Combo 10, and finally a recovered portion of the process fluid (typically water) exiting the invention at clean water outlet

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flange 29. Oil separated during the initial phase of the immiscible fluids separation process is collected in oil collection reservoir (CPI) 16. In like manner, oil separated during the final phase of the immiscible fluids separation process is collected in oil reservoir (IGF) 27. Oil collection reservoir 16 is connected to oil collection reservoir 27 by means of CPI/IGF collected oil reservoir conduit 49. The oil collection in oil collection reservoir (IGF) 27 is the aggregate product of oil separated by IGF processing cell #1 20, IGF processing cell #2 21, IGF processing cell #3 22, and IGF processing cell #4 23. Waste settlement portions of the raw fluid processed by Corrugated Plate Interceptor (CPI) compartmental vessel 3 and induced gas flotation subassembly (IGF) 7 are extracted through first (CPI) drain 40 and second (IGF) drain 41, both of which can be utilized to empty the apparatus of all fluids. Sampling of the raw unprocessed fluid and the processed fluid may be performed at sample connection for inlet 110 and sample connection for outlet 111.

FIG. 2 illustrates a schematic side elevation view of corrugated plate interceptor (CPI) compartmental vessel 3, schematically illustrating the immiscible fluid primary flow path 2 of the raw, contaminated fluid to be processed. Entering by means of the immiscible fluids inlet flange 11, a portion of the raw fluid quickly floats to the surface of the inflow as surface oil 43, the remaining fluid flows to a corrugated plate interceptor pack 15. Removable distribution baffle 12 reduces possible surge pressures from the incoming immiscible fluid. Surface oil 43 and additional oil extracted by corrugated plate interceptor pack 15 both pass into a receptacle for collected oil, oil collection reservoir 16, poring over first adjustable skim weir 50 as surface oil water weir discharge 44. Processed water passing through corrugated plate interceptor pack 15 accumulates in processed fluid compartment (CPI) 45. This process water wells up and passes over first fixed water spill over weir (CPI) 17 as process water weir discharge #1 46, the discharge creating CPI process weir discharged water level 51, the discharge flowing from CPI to IGF transfer chamber 18, which in turn, flows through CPI/IGF transfer conduit 19. Primary solids collection 113, in conjunction with first (CPI) drain 40, provides a means for draining fluid and debris from corrugated plate interceptor (CPI) compartmental vessel 3. Sample collection for inlet 110 can be used to sample the input fluid.

FIG. 3 illustrates a schematic side elevation view of the Induced Gas Flotation (IGF) compartmental vessel 7 schematically depicting the immiscible fluid primary flow path 2 as the fluid passes through CPI/IGF transfer conduit into the conjoint induced gas flotation (IGF) compartmental vessel 7. The finished process fluid (typically water) accumulates in recirculation cell 56, the accumulated water having an IGF process weir discharged water level 53. Water level 53 increases during fluid processing and subsequently flows over second fixed water spillover weir (IGF) 26 as process water weir discharge #2 47 into collected quiescent cell 28. Collected quiescent cell 28 is discharged via clean water outlet flange 29. Sampling of collected quiescent cell 28 is available by means of sample collection for outlet 111. Secondary solids collection 115, in conjunction with the second (IGF) as drain 41, can be utilized to draw off undesirable constituents of the processed fluid and may also be used to empty all fluids from the induced gas flotation (IGF) compartmental vessel 7. Oil collected in corrugated plate interceptor (CPI), compartmental vessel 3 passes into oil collection reservoir (IGF) 27 via CPI/IGF collected oil reservoir conduit 49. A common air pressure is maintained between corrugated plate interceptor (CPI) compartmental vessel 3 and induced gas flotation (IGF) compartmental vessel 7 by means of air equalization ports 30.

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Each of the induced gas flotation (IGF) processing compartments features an IGF cell separation baffle channel 58 to expeditiously maintain fluid circulated within the induced gas flotation (IGF) compartmental vessel 7.

FIG. 4 illustrates a schematic plan view of the corrugated plate interceptor (CPI) compartmental vessel 3 in more detail, showing the immiscible fluid inlet flange 11, sample connection for inlet 110, removable distribution baffle 12, inlet compartment 13, primary separation baffle plate 14, corrugated plate interceptor pack 15, oil collection reservoir (CPI) 16, processed fluid compartment (CPI) 45, first fixed water spillover weir 17, CPI to IGF transfer chamber 18, and common to both corrugated plate interceptor (CPI) compartmental vessel 3 and induced gas flotation (IGF) compartmental vessel 7, the CPI/IGF process separation partition 31. Also schematically illustrated is first (CPI) drain 40.

FIG. 5 illustrates a schematic side elevation view of the corrugated plate interceptor (CPI) compartmental vessel 3, illustrating some of its more important components. Raw immiscible fluid (generally oil and water) enters subassembly 3 at immiscible fluids inlet flange 11, flowing against removable distribution baffle 12 and accumulates in the inlet compartment 13 and can be removed via primary solids collection 113 in conjunction with first (CPI) drain 40. The inflowing raw immiscible fluids fills inlet compartment 13 until it overflows primary separation plate 14 to be processed by corrugated plate interceptor pack 15. Oil floating to the surface as a result of processing by interceptor pack 15 escapes over adjustable oil spillover weir 116 (50), falling into oil collection reservoir (CPI) 16. Collection reservoir 16 is in communication with CPI/IGF collected oil reservoir conduit 49. Water processed by interceptor pack 15 flows through processed fluid compartment (CPI) 45 and subsequently wells up and overflows first fixed water spillover weir (CPI) 17, the processed water spilling into the CPI to IGF transfer chamber 18, that water in turn, flowing through CPI/IGF transfer conduit 19. Sampling of the immiscible fluid can be obtained at sample connection for inlet 110.

FIG. 6 illustrates a basic schematic plan view of the induced gas flotation (IGF) compartmental vessel 7. Partially processed fluid from corrugated plate interceptor (CPI) compartmental vessel 3 (shown in FIG. 5), via CPI/IGF transfer conduit 19, enters the IGF processing cell #1 20. The fluid then flows, in turn, through IGF processing cell #2 21, IGF processing cell #3 22, IGF processing cell #4 23 by means of the IGF cell separation baffle channel 58. The fluid then enters the recirculation cell 56 wells up and overflows the quiescent cell partition 26 and collects in the quiescent cell 28. The remaining cleaned fluid is then DISCHARGED through clean water outlet flange 29. Sampling of the clarified process fluid (typically water) is available at sample connection for outlet 111. A portion of the fluid collected in the recirculation cell 56 is pumped by the recirculation pump 36 (See FIG. 7) through or into the recirculation header 38 (See FIG. 7) and equally distributed to the four (4) eductor discharge pipes 32 (See FIG. 7). The distributed clean water flows under pressure into each eductor for mixing with the blanket gas or other inert gas to create the fine bubble for oil particle removal. Each eductor has an adjustable valve 33 (See FIG. 7) to regulate the mixture of gas and liquid to create the bubbles. Bubbles eject through the bottom of each eductor 39 (See FIG. 8) and rise to the surface attaching to suspended or free oil droplets thus bringing them to a collection point for removal. The separated oil forms a skim that flows over individual adjustable oil spillover weirs 34 and into oil collection reservoir (IGF) 27. This collected oil, along with the

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oil collected from oil collection reservoir (CPI) **16** by means of oil transfer piping **49**, can be sent for further processing.

The four (4) IGF processing cells are located adjacent to CPI/IGF process separation partition **31** and are separated from each other by an IGF separation baffle **24**. IGF processing cell **#4 23** is separated from recirculation cell **56** by IGF separation end plate **25**. Waste material accumulating at the bottom of induced gas flotation compartmental vessel **7** can be withdrawn by means of IGF drain **41**.

FIG. **7** presents a more detailed schematic side elevation view of Induced gas flotation (IGF) compartmental vessel **7**, illustrating the incorporation of a dual eductor **32** in each of the four (4) IGF processing cells. The four (4) IGF processing cells are partitioned from each other by IGF separation plate **24** and IGF separation plate **25**. Each of the four (4) dual eductors features an air mixing valve **33**. Pump suction piping **35** connects recirculation cell **56** to the input for the recirculation pump **36**. The output of recirculation pump **36** is connected to pumps discharge manifold **38** by means of pump discharge piping **37**. Air pressure within induced gas compartmental vessel **7** is equalized by means of multiple air equalization ports **30**. Each of the four (4) IGF processing cells is in communication with oil collection reservoir (IGF) **27**. Oil collected in both oil collection reservoir (IGF) **27** and oil collection reservoir (CPI **16**, (shown in FIG. **5**) is drawn off by means of a common drain via CPI/IGF collected oil reservoir conduit **49**. Immiscible fluid primary flow path **2** is schematically depicted by the large arrows, the immiscible fluid flowing through CPI/IGF transfer conduit **19**. Conduit **19** pierces CPI/IGF process separation partition **31** to provide fluid communication between corrugated plate interceptor (CPI) compartmental vessel **3** and induced gas flotation (IGF) compartmental vessel **7**. As schematically illustrated by immiscible primary fluids flow path **2**, the processed fluid enters recirculation cell **56** welling up and overflowing quiescent cell partition **26**. Upon overflowing quiescent cell partition **26**, processed water (typically water) accumulates in quiescent cell **28**, where it can be withdrawn through clean water outlet flange **29**. Debris and waste products resulting from processing by the induced gas flotation (IGF) compartmental vessel **7** can be removed by means of second (IGF) drain **41**.

FIG. **8** schematically depicts an end elevation view of the preferred embodiment of the present invention, Enviro-Cell-Combo **10**, comprising both corrugated plate interceptor (CPI) compartmental vessel **3** and induced gas flotation (IGF) compartmental vessel **7**. Piercing CPI/IGF process separation baffle **31**, CPI/IGF transfer conduit **19** provides processed fluids communication between vessel **3** and vessel **7**, conduit **19** linking the CPI/IGF transfer chamber **18**, in similar manner, piercing, CPI/IGF process separation partition **31**, CPI/IGF collected oil reservoir conduit **49** provided oil collection communication between vessel **3** and vessel **7**, conduit **49** linking to oil collection reservoir (IGF) **27**. A portion of the fluid that is to be additionally processed is pumped into the pump discharge manifold **38**, hence to a dual eductor **32**, one (1) each in each of the four (4) IGF processing cells. Each dual eductor **32** features an air mixing valve **33**, controlling a source of gas injection port **57**. The fluid to be additionally processed is combined with a controlled gas injection, the combination ejected from eductor nozzle **39** of each of the four (4) partitioned IGF processing cells. The eductor nozzle **39**, of each of the four (4) dual eductors **32** is positioned to create IGF processing cell counterclockwise fluid circulation **54** in the vertical plane of the fluid processed and accumulated in each of the four (4) partitioned IGF processing cells. This clockwise rotation as shown in FIG. **8** migrates the collected

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oil skim to the pair of individually adjustable oil spillover weirs (IGF **34** adjustable oil weir. The level of the process and accumulated fluid, IGF processing cell fluid level **42** increases during processing until the released surface oil overflows a pair of individually adjustable oil spillover weirs (IGF) **34** in each of the four (4) IGF processing cells, the spillover oil dropping into oil collection reservoir (IGF) **27**. An access port **55** is provided for each of the four (4) IGF processing cells, allowing for inspection and routine maintenance.

PARTS LIST

The following is a list of suitable parts and materials for the various elements of the preferred embodiment of the present invention.

Part No.	Description
2	flow path
3	(CPI) vessel
7	(IGF) compartmental vessel
10	enviro-cell combo
11	method
11	fluid inlet flange
12	baffle
13	inlet compartment
14	baffle plate
15	interceptor pack
16	oil collection reservoir (CPI)
17	water spillable weir
18	IGF transfer chamber
19	CPI/IGF transfer conduit
20	IGF processing cell #1
21	IGF processing cell #2
22	IGF processing cell #3
23	IGF processing cell #4
25	plate
26	spillover weir IGF
27	oil reservoir (IGF)
28	quiescent cell
29	water outlet flange
30	air equalization ports
31	separation partition
32	discharge pipes
33	adjustable valve
34	spillable weirs
35	pump suction piping
36	recirculation pump
37	discharge piping
38	circulation header
39	eductor
40	(CPI) drain
41	(IGF) drain
43	subsurface oil
44	oil water weir discharge
45	processed fluid compartment (CPI)
46	water weir discharge #1
49	oil reservoir conduit
50	skim weir
51	discharge water level
53	water level
56	recirculation cell
57	gas injection port
58	baffle channel
110	inlet
111	outlet
113	primary solids collection
115	secondary solids collection
146	water weir discharge
247	discharge

All measurements disclosed herein are at standard temperature and pressure, at sea level on Earth, unless indicated otherwise. All materials used or intended to be used in a human being are biocompatible, unless indicated otherwise.

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The foregoing embodiments are presented by way of example only; the scope of the present invention is to be limited only by the following claims.

The invention claimed is:

1. A method of separating two fluids, one lighter in specific gravity than the other, comprising the following steps:

providing a single vessel, having a primary separation chamber and a gas flotation chamber and a conduit for providing flow from the primary separation chamber to the gas flotation chamber;

flowing fluids into the primary separation chamber of the vessel;

separating free and suspended solids, including free oil, grease and gas, from the fluids by utilizing parallel corrugated plates in the primary separation chamber for defining the distance of rise for a given oil droplet to remove the remaining smaller droplets of free oil and solids from the fluids;

flowing the fluids from the primary separation chamber into the gas flotation chamber and inducing gas into the fluids to provide a finely dispersed bubble in the fluids to accelerate the lift necessary for separation of fine oil droplets, emulsified oil droplets, and suspended solids;

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creating a rotation of gas introduced into the fluids to move the separated fine oil droplets, emulsified oil droplets, and suspended solids to a spillover point in the gas flotation chamber for collection;

flowing fluid that has been processed through the vessel through an outlet of the gas flotation chamber; and wherein fluid flow into and through the primary separation chamber flows in a direction counter to the flow of fluid through the gas flotation chamber to the outlet.

2. The method in claim 1, wherein the process within the single vessel provides the proper flow regime and unique hydraulic condition for undisturbed flow throughout the vessel, into and from the primary separation chamber to the gas flotation chamber to the outlet thru a specified pressure drop internal to the vessel.

3. The method in claim 1, further comprising the step of flowing the gas through the fluid in a counter clockwise direction so that smaller oil droplets are collected from the fluid and rise to the top of the fluid, to further clean the fluid.

4. The method in claim 3, wherein the fluid is then pumped into one or more eductors for further mixing with the gas and for circulating back into the processing cells, for more oil removal from the fluid.

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